



# Observations on the Effects of the Hail on Some Apple Varieties under the Conditions of 2021

Simona-Mihaela CHELARU, Agurița Aftudor MANOLACHE,  
Mădălina Iuliana GHERGHEL, Ionel PERJU, Cristina Ionela TURCU\*

Research Station for Fruit Growing Iași, 3 Ion Vodă cel Viteaz Street, Miroslava, 707305, Iași, Romania

\*Corresponding author: C.I. Turcu e-mail: [ing.cristinaboboc@gmail.com](mailto:ing.cristinaboboc@gmail.com)

## RESEARCH ARTICLE

### Abstract

The research was carried out on 3 apple varieties, namely Golden delicious, Jonathan and Starkrimson, grown in the N-E area of Romania, within the Research Station for fruit growing Iași, on Fălticeni development center. The plantation was established in 1990, being in 31 since planting. The trees are grafted on the MM106 rootstock, with a planting distance of 4 meters between rows and 2.5 meters between trees, with a density of 1000 trees/ha. During the agricultural year 2021, hail was observed as an extreme climatic phenomenon, recorded in June, July and August, when the trees were in the phenological stage BBCH 71-74, BBCH 75, BBCH 77 and BBCH 79. Extreme phenomena were accompanied by heavy rains and storms that affected both the quality and quantity of fruit production. The highest degree of damage was recorded in the Golden delicious variety in all four hail falls, with a percentage between 5% and 67%. Therefore, the fruit production was affected, their quality being impaired and not being commercialized as high quality fruit, for fresh consumption, but only industrialized.

**Keywords:** climate accidents, hail, apple


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## INTRODUCTION

The apple is a very ancient species, cultivated for thousands of years. The apple species is also remembered in religious books as the symbol of the knowledge of evil. Scientific data have shown that the apple has been in the culture for more than 7500 years. It is currently the most cultivated species in temperate climates, occupying very large areas. In terms of production, the apple ranks 4 worldwide, after bananas, citrus and grapes, in our country occupying an area of about 54 000 ha with an average production of 12 t/ha according to FAO 2019. One of the challenges facing farmers is the hail. Hail is a form of solid precipitation made up of transparent or opaque ice granules of various shapes, sizes and weight, which falls during rain showers, accompanied by orajous phenomena (thunder and lightning) and strong wind, taking the appearance of a storm. (*Instructions for weather stations and ports*, 1963). Once it appears, this phenomenon causes colossal damage to plantations, affecting the biological cycle of the plant, considerably reducing the production and quality of the fruit. The damage caused favors the appearance of certain pathogens and pests, so a single fall of hail in a critical phase of plant development can compromise the entire crop. The appearance of hail in the phenofase of alert growth of fruits (BBCH 71) caused a slow growth of apples and their deformation, the biological processes of plants being slowed down. The purpose of this study is to analyze the resistance of the apple varieties existing in the plantation, to the damage caused by hail and to

develop a strategy for managing the risks produced by it.

## MATERIAL AND METHOD

The observations were made in an apple plantation, located in the North-East area of Romania, within the Research Station for fruit growing Iasi, on Fălticeni development center, on three apple varieties, namely Golden delicious, Starkrimson and Jonathan. The plantation was established in 1990, being in 31 since planting. The trees are grafted on the MM106 rootstock, with a planting distance of 4 meters between rows and 2.5 meters between trees, with a density of 1000 trees/ha.

The BBCH monograph was used to determine the phenological stage of the trees at the time of the appearance of hail.

During the agricultural year 2021, there were 4 hail falls, in different growth phenofases of the trees according to the BBCH monograph. After each hail fall, 100 fruits of each variety were analyzed, of three repetitions each.

A side effect of the hail fall was the appearance of the pathogen *Monilinia fructigena* (Aderh et Ruhl), for which 100 fruits were analyzed after the last hail fall. The pathogen was installed in the wounds caused by all 4 climate accidents.

The samples were analyzed in the research laboratory of the unit, recording the number of wounds and their size. The data were used to calculate the degree of damage of the hail and moniliosis on the fruit (Normes OEPP, 2004).

Frequency (F%) is the relative value of the number of plants or organs of the attacked plant (n) in relation to the number of plants or organs observed (N).

It is calculated by the formula:

$$F \% = \frac{n \times 100}{n}$$

The intensity of the attack is expressed% in relation to the number of plants or organs of the plant attacked (n). The calculation formula is:

$$I \% = \frac{i \times f}{n}$$

where:

i = the percentage of attack of the organ (corresponding to the note in percentage);

f = number of attack cases per note;

n = total number of cases.

The degree of damage is calculated by the relationship:

$$GA \% = \frac{I \% \times F \%}{100}$$

where:

I = intensity

F = frequency

## RESULTS AND DISCUSSIONS

The frequency of the appearance of hail in the agricultural year 2020-2021 represents the negative effect of temperature fluctuations caused by climate change, the high minimum temperature being related to the appearance of hail ("W.J.W.Botzenet et al. 2010).

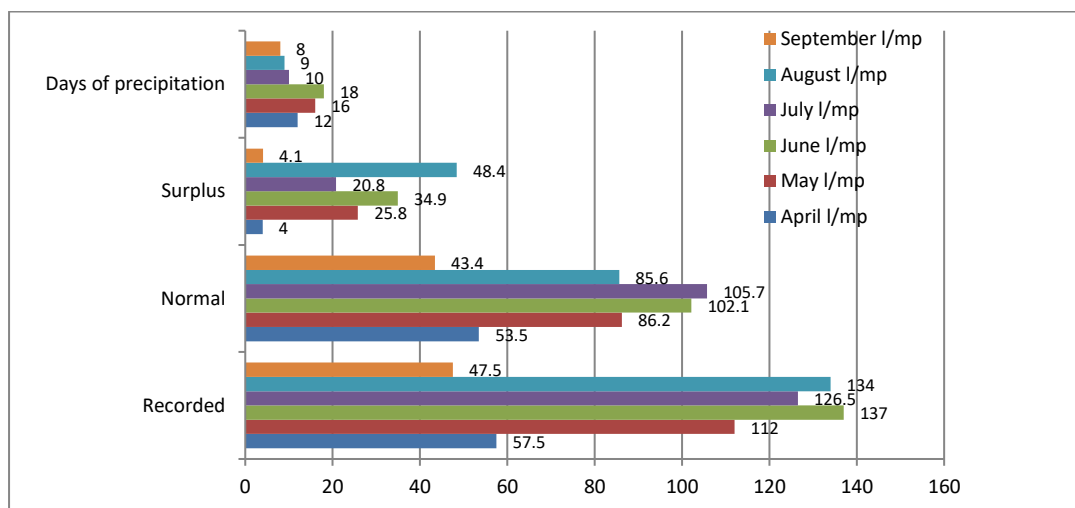
From a climatic point of view, in the agricultural year 01.10.2020-30.09.2021, Fălticeni recorded an average annual temperature of 9.1°C and a precipitation amount of 918.2 mm. From a thermal point of view it was a warm year, with a thermal surplus of 1.1°C compared to the multi-annual average temperature of 8.0°C. Monthly, there was a thermal surplus, except for April, May and September, which were colder than the multiannual monthly average by 0.4-2.0°C. In terms of precipitation, the year was rainy, with a precipitation surplus of 272.1 mm compared to the multiannual normal value of 646.1 mm.

The agricultural year 2020-2021, recorded a monthly surplus of precipitation (Figure 1), with the exception of November, which recorded a deficit of 22.2 mm. In the spring, (April - May), when the trees started in vegetation, temperatures were very low, which led to a very slow evolution in the growth and fruiting of the trees (Table 2).

During the vegetation period, large amounts of precipitation were recorded in June, 137.0 mm (normal 102.1 mm) and 104.2 mm in October (normal 30.1 mm).

The number of days with precipitation oscillated between 3 days (November) and 16-18 days (May and June). This year there were 130 days of rainfall, of which 73 days during the growing season. The rainiest month was June, with 18 days of precipitation. The large amount of precipitation from April to June, as well as the large number of days of rainfall during this period (46 days), created very favorable conditions for primary scab and monyliosia infections. Relative air humidity was between 67% in April and 91% in December.

During the year, the lowest temperature was  $-18.0^{\circ}\text{C}$  and was recorded on 19.01.2021. The highest temperature of  $33.0^{\circ}\text{C}$  was recorded on 31.07.2021, the summer being rainy and warm, with a monthly thermal surplus between 0.9 and  $3.4^{\circ}\text{C}$ . The first autumn frost ( $-0.5^{\circ}\text{C}$  in the air) occurred on 02.11.2020, and the last spring frost ( $-3.0^{\circ}\text{C}$  in the air) on 09.04.2021, without major negative influences on the trees.



**Figure 1-** The amount of precipitation recorded during the vegetation period of 2021, at C.D. Fälticeni

In the wounds produced by hail, the pathogen *Monilinia fructigena* was installed, the attack of this pathogen recorded high values in the Jonathan variety (62.05% degree of damage), followed by the Golden delicious variety with an attack degree of 49.92%, The most resistant was the Starkrimson variety to the attack of *Monilinia fructigena* Table 1.

**Table 1.** The attack of *M. fructigena*, on apple in 2021

Apple cultivar	<i>Monilinia fructigena</i>		
	Frequency %	Intensity %	Attack Degree %
Jonathan	73	85	62.05
Golden delicious	64	78	49.92
Starkrimson	52	72	37.44

In 2021, hail was recorded as an extreme climatic phenomenon, repeatedly falling (on 30 June, 19 July, 28 July and 24 August), accompanied by heavy rains and storms that affected both the quality and production of fruit, the plantations in the Fälticeni area were also affected. During the vegetation period of 2021, the hail was first recorded on June 30, being small in size (0.5-1.0 cm) and with low intensity, accompanied by storms and electrical discharge, the trees were phenologically at BBCH 71-74.

On July 19, the second hailfall of the agricultural year studied was recorded, due to the storm and large temperature differences, accompanied by strong precipitation (39 mm), which continued the next day (28 mm), totaling 63.0 mm., the apple culture being at BBCH 75.

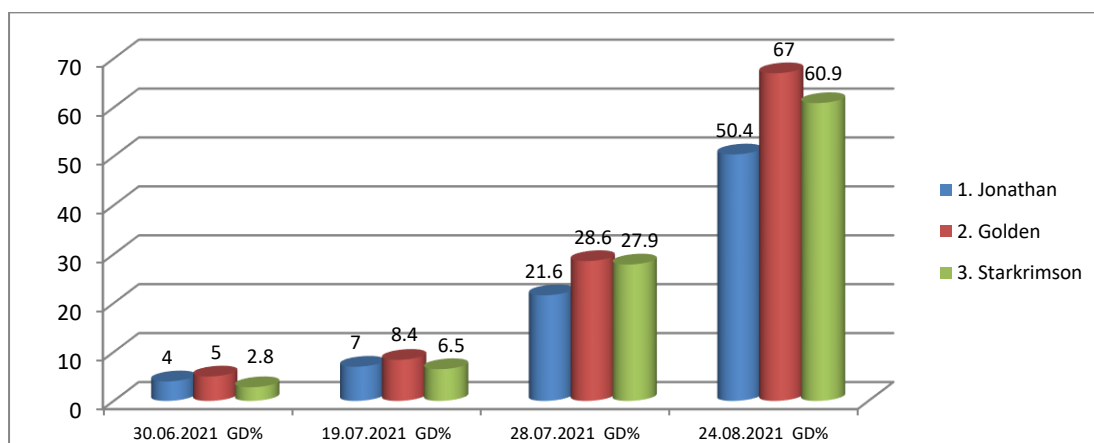
On July 28, there was a new fall of hail, (the third in the vegetation period and the second in July), the trees were at BBCH 77, the hail was small in size (0.5 cm), but of high intensity, accompanied by storms and precipitation in the amount of 25 mm.

The last climate accident in the 2021 vegetation season was recorded on August 24, but this time the hail was angular, with a diameter between 0.5 and 2.0 cm, accompanied by a strong storm and precipitation of 29.5 mm.

**Table 2.** The main phenological phases recorded in the apple species under the conditions of 2021 at C.D. Fälticeni

BBCH	VARIETY		
	Jonathan	Golden	Starkrimson
BBCH 01	09.04.2021	12.04.2021	07.04.2021
BBCH 03-09	19.04.2021	22.04.2021	20.04.2021
BBCH 10-19	29.04.2021	04.05.2021	30.04.2021
BBCH 30-39	30.04.2021	05.05.2021	04.05.2021
BBCH 50-59	02.05.2021	08.05.2021	07.05.2021
BBCH 60	07.05.2021	10.05.2021	08.05.2021
BBCH 61-68	10.05.2021	12.05.2021	11.05.2021
BBCH 69	17.05.2021	19.05.2021	18.05.2021
BBCH 72-74	25.05.2021	27.05.2021	26.05.2021
BBCH 74-76	09.07.2021	05.07.2021	05.07.2021
BBCH 79-89	18.10.2021	15.10.2021	11.10.2021

Observations and determinations of the frequency, intensity and degree of damage of the fruit were made in the first three days after each repeatedly recorded hail, during the growing season of 2021, according to the table above. The degree of damage of the fruits produced by hail was between 2.8-67% (Figure 2).



**Figure 2.** The degree of damage of the girder recorded during the vegetation period of 2021, at CD Fälticeni

The lowest 2.8% was recorded after the first hail of the Starkrimson variety, and the largest was recorded after the August 24 hail of the Golden delicious variety by 67% (Figure 3).



**Figure 3.** Hail effect - Golden delicious variety (original)

For each hail fall, the most affected variety was Golden delicious, so on June 30 the attack rate was 5%, on July 19, 8.4%, on July 28, 28.6%, and at the last hail, the degree of damage was 67%.

In the other two varieties we can see that the phenofase of development was a factor of resistance, so that at the first two drops of hail the Starkrimson variety was less affected than the Jonathan variety, and at the last two falls the Starkrimson variety showed a weaker resistance to hail attack, being more affected than the Jonathan variety.

## CONCLUSIONS

In conclusion, from the obtained results, we note that the most sensitive to the attack caused by hail was the Golden delicious variety, having the highest percentage of the attack degree of all 4 periods in which climate accidents were recorded, followed by the other varieties that registered different results, the Jonathan variety is more affected than the Starkrimson variety in the first 2 periods and less affected than the same variety in the last 2 periods.

At the same time, we can conclude that the stage of vegetation in which the trees were located significantly influenced the degree of damage so that with the hail, the storms and the abundant rainfall led to impairments in both the quality and quantity of the fruits.

The large amount of precipitation in April-June, as well as the high number of days of rainfall during this period (46 days), created very favorable conditions for primary scab and monyliosis infections. Relative air humidity was between 67% in April and 91% in December.

Fruit growth was very slow during June-September due to the hailage recorded repeatedly during this period of 2021.

Therefore, based on the observations made on the climate data, the phenological stage and the physical analyzes of the fruits, we can conclude that the apples were impaired following the attack caused by hail which subsequently favored the occurrence of the pathogen *Monilinia fructigena*.

Of the varieties analyzed the most affected by hail, after the four accidents, is the Golden delicious variety with 67% and the most affected by the installation of moniliosis in the wounds caused by hail is the Jonathan variety with an attack percentage of 62.05%.

The lowest fruit production was recorded in the Golden delicious variety, with the optimal consumption of apples amounting to only 33%.

The losses recorded in the studied plantations as well as in the plantations in the Falticeni area could have been reduced by the existence of an anti-hail station in the area (PNDR 2014-2020 Climate risk mitigation through methods and devices to combat hail falls) and by the modernization of the plantations with anti-hail net.

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## Conflicts of Interest

The authors declare that they do not have any conflict of interest.

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